Thermophysical Properties of CVD-Diamond of Different Quality

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Diamond is the material with the highest thermal conductivity within the temperature region between 200 – 600 K. At room temperature natural diamond reaches thermal conductivity values of 2400 W/mK and diamond wafers of best quality produced by the CVD (Chemical Vapor Deposition) – method also approach this maximum value. Since the thermal conductivity is strongly affected by point defects, internal and external boundaries and foreign phases, its value can serve as a measure of quality. Therefore the thermal conductivity value measured at room temperature can be used to classify the specific CVD-diamond wafer along with its optical absorption.

The thermal diffusivity of CVD-diamond wafers from different suppliers was measured with a specific photoacoustic setup. Some of samples were irradiated with fast neutrons to study the effects of additional point defects on the thermal conductivity. The measurements were performed with the heat flow along the surface normal of the wafers. The thermal conductivity was calculated by using specific heat values which were measured at selected wafers with a differential scanning calorimeter.

The experimental results show a strong dependence of the thermal conductivity on the thickness and also on the optical transmission of the diamond-wafers. The thermal conductivity increases with increasing thickness which can be explained with the specific microstructure of diamond. Opaque diamond samples (“black diamond”) exhibits a lower thermal conductivity compared to the samples with high optical transmission values (“white diamond”). Graphite like phases seem to be important for the reduction of the thermal conductivity in the black diamond which shows values between 800 and 1500 W/mK whereas point defects tend to reduce the thermal conductivity of the white diamond samples which could be confirmed by measurements on neutron irradiated diamond wafers. The experimental results will be discussed within different models for heat transport in layered materials.